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Maryland Climate Bulletin
June 2023

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DEPARTMENT OF ATMOSPHERIC & OCEANIC SCIENCE
Sumant Nigam, Chair

Maryland State Climatologist Office

Summary

Statewide averages show that June 2023 was colder and drier than normal (i.e., 1991-2020 averages). Monthly mean temperatures were between 60 to 73°F; maximum temperatures were in the 71 to 83°F range, and minimum temperatures were between 48 to 62°F. Monthly total precipitation was in the 2 to 5 inches range.

Maryland Regional Features (Figures 1-5, C1, and D1)

- Mean temperature was colder than normal everywhere, notably in Washington, Allegany, and Garrett counties (above 3.9°F), and parts of Charles, Calvert, and Saint Mary's counties, as well as portions of Harford, Cecil, Kent, and Queen Anne's counties (above 2.7°F).

- Maximum temperature was also colder than normal everywhere, especially over Washington, Allegany, and Garrett counties (3.0°F and above) and portions of Charles, Anne Arundel, Calvert, and Saint Mary's counties, as well as portions of Harford, Kent, Queen Anne's, and Talbot counties (above 2.1°F).

- Minimum temperature was colder than normal everywhere, notably in Washington, Allegany, and Garret counties (above 5.1F), Frederick and Carroll counties (4.2°F and above), and Harford and Cecil counties (above 3.9°F).

- Precipitation was below normal almost everywhere, especially over Montgomery and portions of Frederick, Carroll, and Howard counties (above 2.1 inches); and parts of Prince George's, Calvert, Saint Mary's, Talbot, and Dorchester counties (above 1.5 inches). Normal to above-normal precipitation was only over Baltimore City and portions of Baltimore and Anne Arundel counties.

- The extent of the surface in the state under drought conditions increased from around 66% at the end of May to around 93% at the end of June. Around 33% of the state is under abnormally dry conditions (especially over Garret and Allegany counties and around the eastern shore counties); the extent under moderate drought conditions occupies now around 38% of the state (largely over the north-central counties and western shore counties); and severe drought conditions appear for the first time occupying around 23% of the state (over almost all the counties of the Piedmont). The persistence of below-normal precipitation over almost the whole state seems to be behind the worsening drought conditions.

Maryland Climate Divisions (Figures 6-7, B1, and B2)

- All eight climate divisions were colder and drier than normal in June. Anomalies for climate divisions 2−4, along the Chesapeake Bay, were drier and less cold than anomalies in climate divisions 7 and 8 in the northwest of the state.
- Statewide temperature and precipitation anomalies remained cold and dry. While wet and warm anomalies (0.41 in, 3.7°F) were present in April, dry and cold anomalies appeared in May (−2.23 in, −2.4°F) and have persisted in June (−1.10 in, −2.7°F).

Historical Context (Figure 8, Tables A1 and A2)

- June's mean, maximum, and minimum statewide temperatures (69.4, 80.6, and 58.1°F) were below the long-term (1895-2022) average and within 25% of the coldest Junes. June's precipitation (3.11 in) was below the long-term average and far from the record.
- Mean temperature ranked 7th among the coldest Junes for Allegany County, 9th for Garrett County, and 11th for Washington County. While maximum temperatures did not rank in the coldest ten, minimum temperatures, on the other hand, ranked 1st for Allegany County and 3rd for Garrett and Washington counties among the coldest temperatures.

Century-Plus Trends, 1895-2023 (Figures 9, 10)

- June statewide temperature and cooling degree days showed significant increasing trends: a warming trend (1.7°F/century), and an increasing trend (49.04°FDD), respectively. Statewide precipitation had no significant increasing trend (0.07 in/century).
- Regionally, June temperatures showed significant warming trends almost everywhere. Notably, the largest trend is in Baltimore City (2.8°F/century), as it has been in April and May. Trends above 2.0°F/century are also evident in Baltimore County and portions of Carroll, Harford, Howard, Montgomery, Prince George's, and Anne Arundel counties, as well as in the eastern shore in Wicomico, Somerset, and Worcester counties and portions of Queen Anne's, Caroline, Talbot, and Dorchester counties.
- Regionally, June precipitation has a small region of significant wet trends over northern Cecil County (~0.8 in/century). The largest no significant wet trends (around 0.6 in/century range) are over Harford, Cecil, and Kent counties, while the largest drying trends (0.5-0.6 7 in/century range) are over Washington County and portions of Charles County.

Contents

1. Introduction

The Maryland Climate Bulletin is issued by the Maryland State Climatologist Office (MDSCO), which resides in the Department of Atmospheric and Oceanic Science at the University of Maryland, College Park. It documents the surface climate conditions observed across the state in a calendar month and is issued in the second week of the following month.

Maryland's geography is challenging, with the Allegheny and Blue Ridge mountains to the west, Piedmont Plateau in the center, the Chesapeake Bay, and the Atlantic Coastal Plain to the east. The range of physiographic features and the eastern placement of the state within the expansive North American continent contribute to a comparatively wide range of climatic conditions.

The bulletin seeks to document and characterize monthly surface climate conditions statewide, and climate division and county-wise, placing them in the context of regional and continental climate variability and change to help Marylanders interpret and understand recent climate conditions.

The monthly surface climate conditions for June 2023 are presented via maps of key variables, such as average surface air temperature, maximum surface air temperature, minimum surface air temperature, total precipitation, and their anomalies (i.e., departures from normal); they are complemented by drought conditions for the state, as given by the U.S. Drought Monitor (Section 3). Statewide and climate division averages for the month are compared against each other via scatter plots (Section 4). The monthly statewide averages are placed in the context of the historical record via box and whisker plots in Section 5. Century-plus trends in statewide air temperature, cooling degree-days, precipitation, and state maps of air temperature and precipitation are presented in Section 6. Ancillary statewide, climate division, and county-level information is provided via tables and plots in Appendices A-B; climatology and variability maps are in Appendices C-D.

2. Data

Surface air temperatures, total precipitation, and cooling degree-days data in this report are from the following sources:

- NOAA Monthly U.S. Climate *Gridded* Dataset at 5-km horizontal resolution (NClimGrid – Vose et al. 2014), which is available in a preliminary status at:
  https://www.ncei.noaa.gov/data/nclimgrid-monthly/access/
  Data was downloaded on 7/13/2023.

- NOAA Monthly U.S. Climate *Divisional* Dataset (NClimDiv – Vose et al. 2014), which is available in a preliminary status (v1.0.0-20230707) at:
  https://www.ncei.noaa.gov/pub/data/cirs/climdiv/
  Data was downloaded on 7/13/2023.

The drought conditions are from the U.S. Drought Monitor website: https://droughtmonitor.unl.edu/Maps/MapArchive.aspx

Some definitions:

About the anomalies: Anomalies for a given month (e.g., June 2023) are the departures of the monthly value from the corresponding month's 30-year average (i.e., from the average of 30 Junes) during 1991-2020; the 30-year average (or mean) is the climate normal, or just the climatology. When the observed monthly value exceeds its climatological value, it is referred to as above-normal (e.g., warmer than normal or wetter than normal) or a positive anomaly. In contrast, when this value is smaller than its climatological value, it is referred to as below-normal (e.g., colder than normal or drier than normal) or negative anomaly.

About NOAA's Climate Divisions. The term "climate division" refers to one of the eight divisions in the state that represent climatically homogeneous regions, as determined by NOAA: https://www.ncei.noaa.gov/access/monitoring/dyk/us-climate-divisions

The eight climate divisions in Maryland are:

- Climate Division 1: Southeastern Shore. It includes the counties of Somerset, Wicomico, and Worcester.
- Climate Division 2: Central Eastern Shore. It includes the counties of Caroline, Dorchester, and Talbot.
- Climate Division 3: Lower Southern. It includes the counties of Calvert, Charles, and St. Mary's.
- Climate Division 4: Upper Southern. It includes the counties of Anne Arundel and Prince George's.
- Climate Division 5: Northeastern Shore. It includes the counties of Kent and Queen Anne's.
- Climate Division 6: North Central. It includes the counties of Baltimore, Carroll, Cecil, Frederick, Harford, Howard, Montgomery, and the city of Baltimore.
- Climate Division 7: Appalachian Mountains. It includes the counties of Allegany and Washington.
- Climate Division 8: Allegheny Plateau. It includes Garrett County.

Note that these Climate Divisions do not correspond with the *Physiographic Provinces* in the state, as the former follow county lines. Climate Division 8 follows the *Appalachian Plateau Province*, Climate Division 7 follows the *Ridge and Valley Province*; however, Climate Division 6 includes the *Blue Ridge and the Piedmont Plateau provinces*, Climate Divisions 3, 4, and a portion of 6 include the *Upper Coastal Plain Province*, and Climate Divisions 1, 2, 5, and a portion of 6 include the *Lower Coastal Plain (or Atlantic Continental Shelf) Province*.

3. June 2023 Maps

A. Mean Temperatures

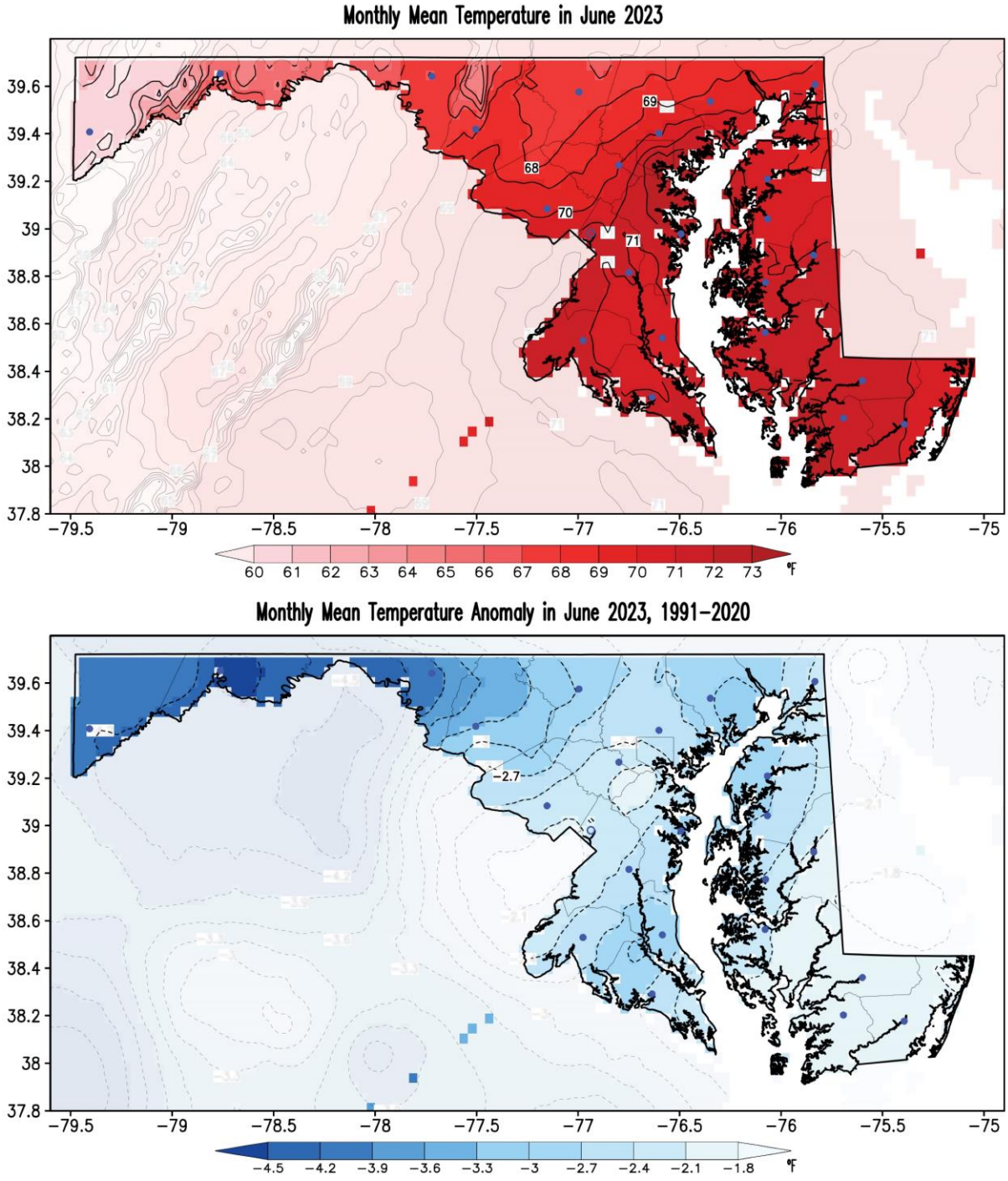

Figure 1. Monthly mean surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for June 2023. Temperatures are in °F following the color bar. Blue shading in the anomaly map marks colder than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

B. Maximum Temperatures

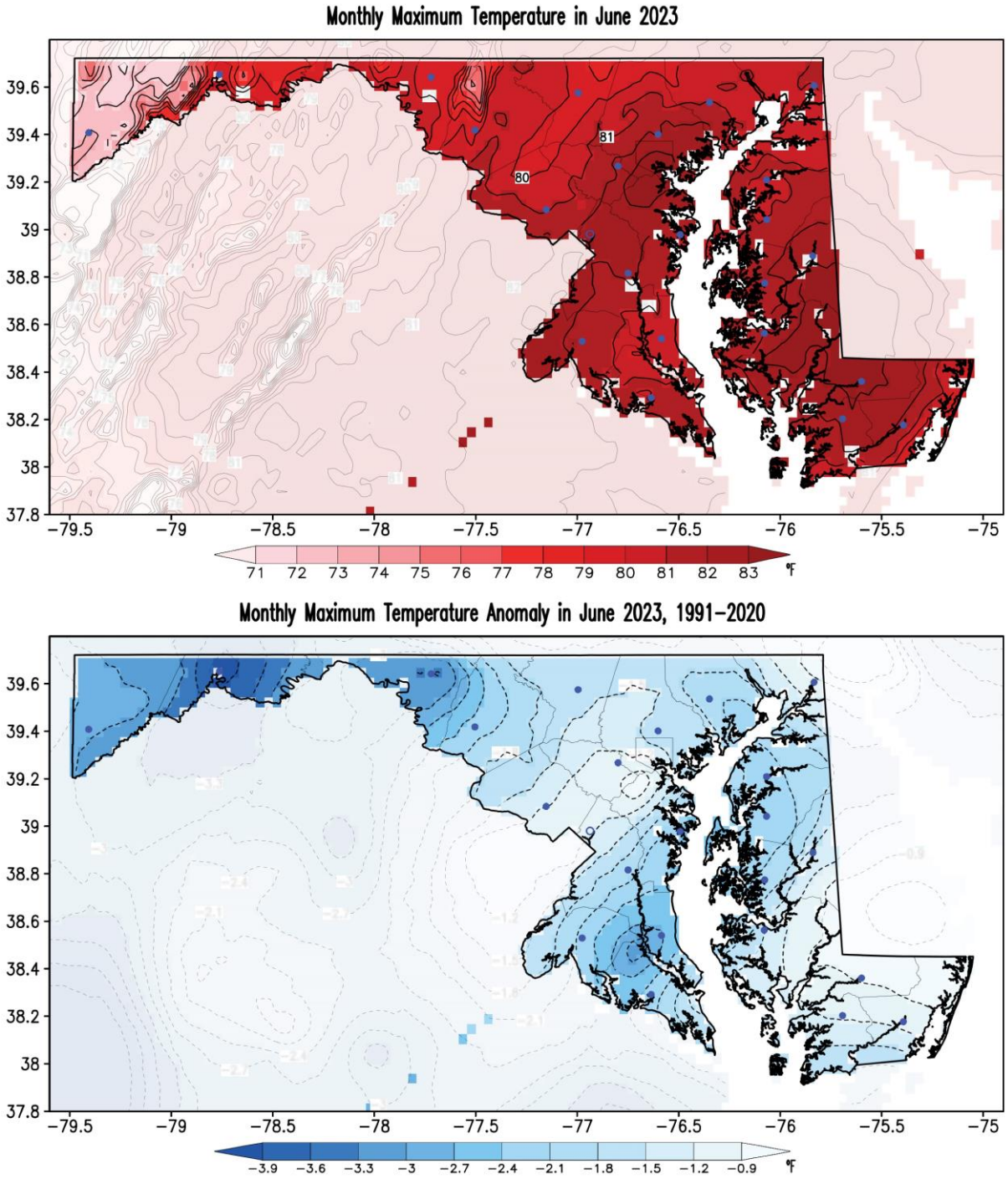

Figure 2. Monthly maximum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for June 2023. Temperatures are in °F following the color bar. Blue shading in the anomaly map marks colder than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

C. Minimum Temperatures

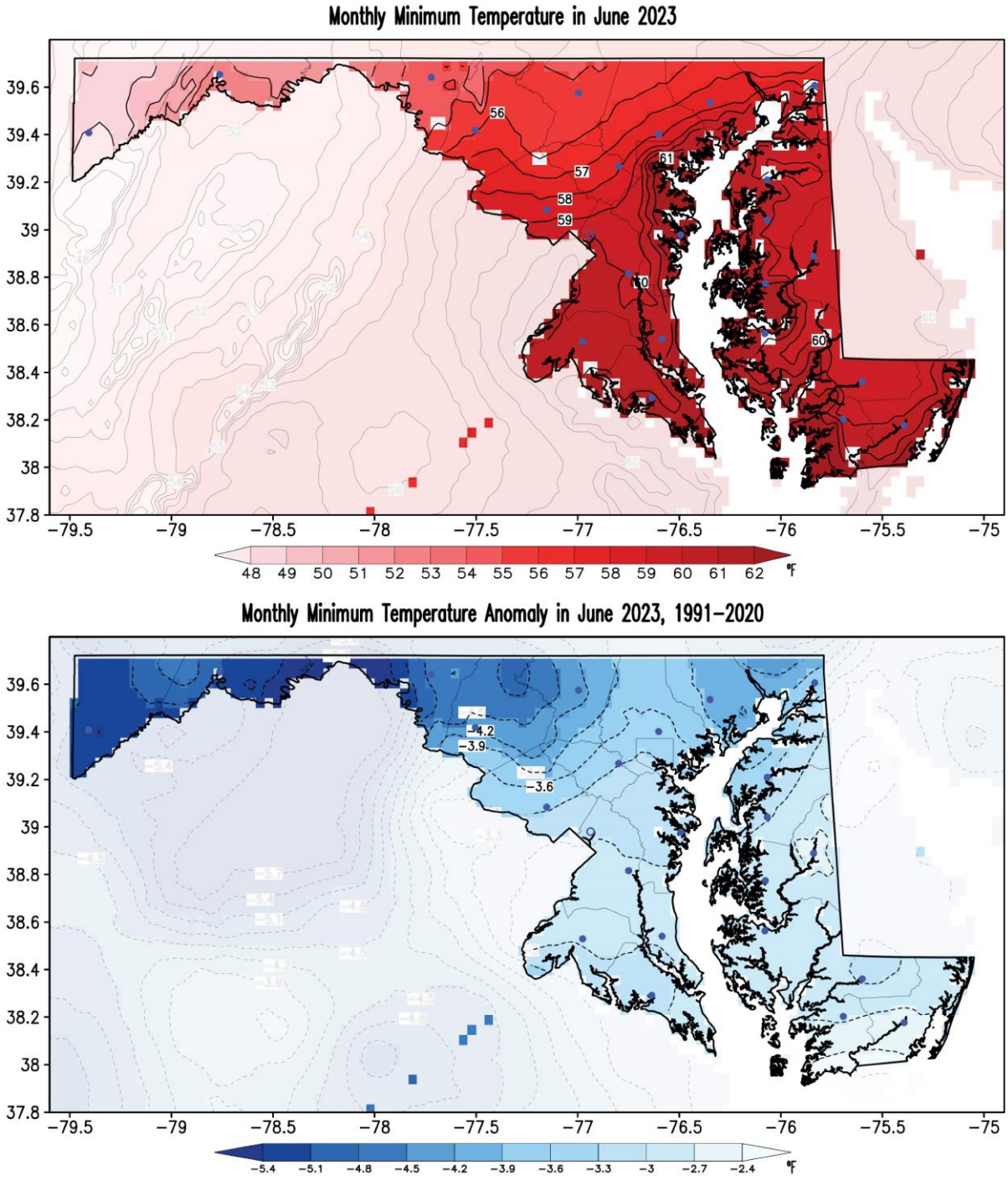

Figure 3. Monthly minimum surface air temperature (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for June 2023. Temperatures are in °F following the color bar. Blue shading in the anomaly map marks colder than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

D. Precipitation

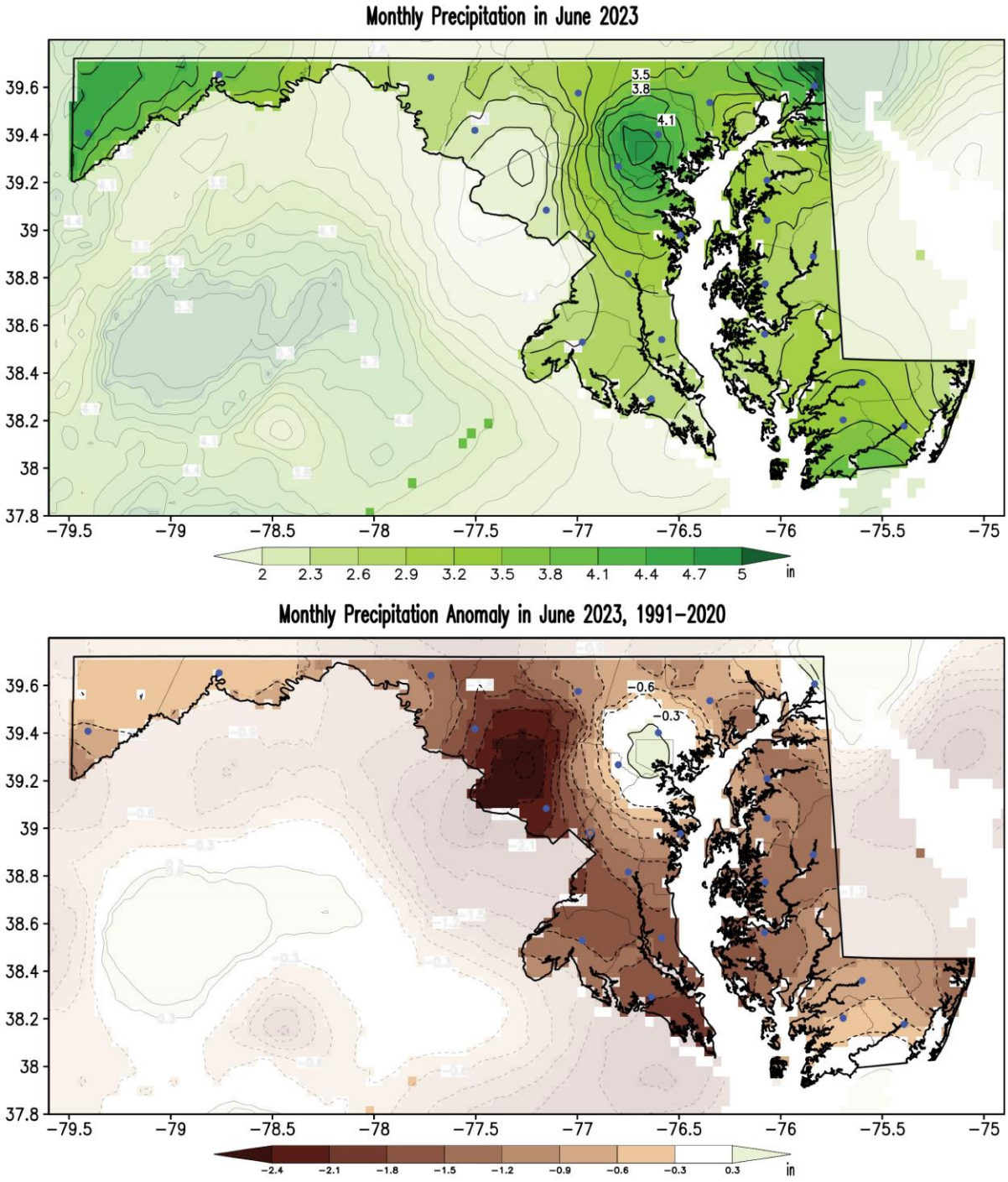

Figure 4. Monthly total precipitation (top panel) and its anomaly with respect to the 1991-2020 climatology (bottom panel) for June 2023. Precipitation is in inches following the color bar. Brown/green shading in the anomaly map marks drier/wetter than normal conditions. Note shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

E. Drought

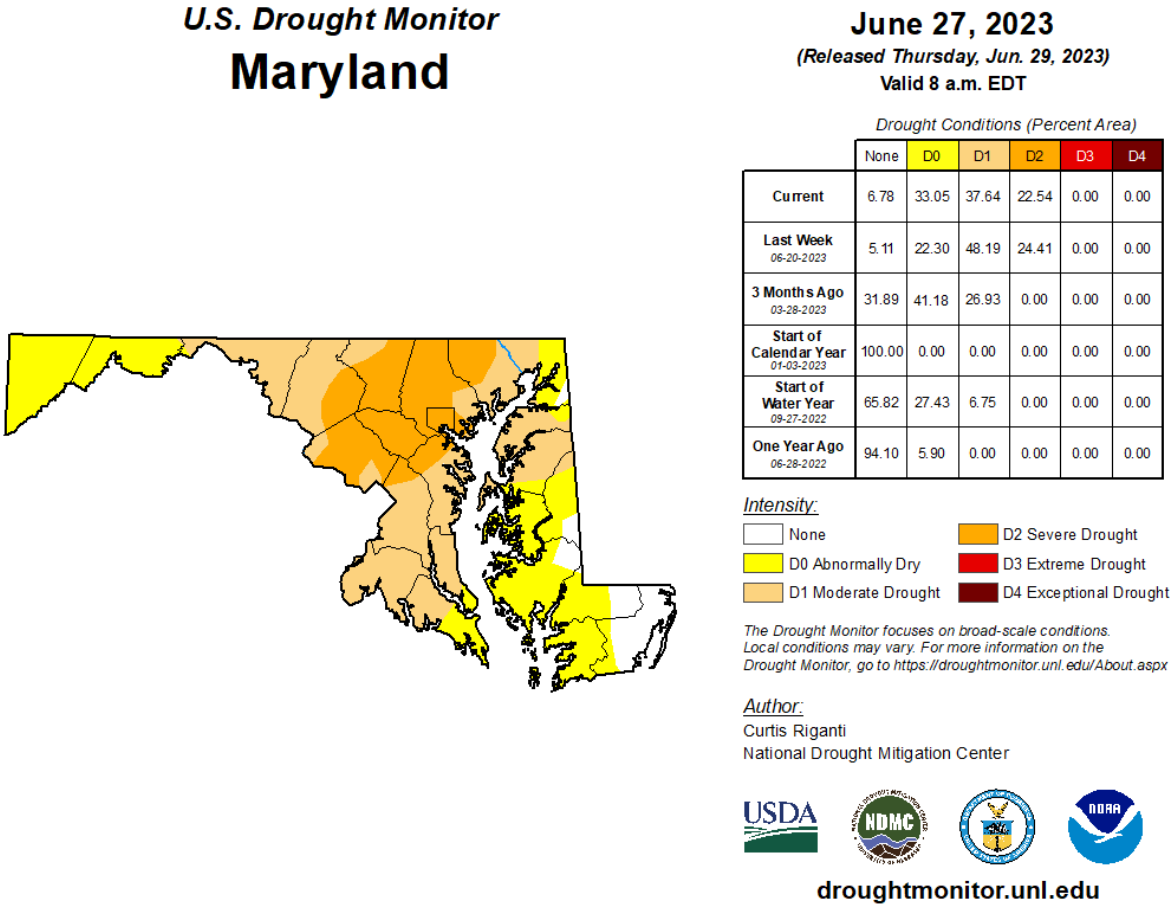

Figure 5. Drought conditions as reported by the U.S. Drought Monitor on June 27, 2023. Yellow shading indicates regions that are abnormally dry, regions with light orange shading shows regions that are under a moderate drought, and regions with darker orange are regions under severe drought according to the inset of drought intensity. Numbers in the table indicate the percentage of the state covered under the particular drought conditions at the cited time in the left column. At this time, 93.23% of the state was under some drought category.

4. June and AMJ 2023 Climate Divisions Averages

A. June 2023 Scatter Plots

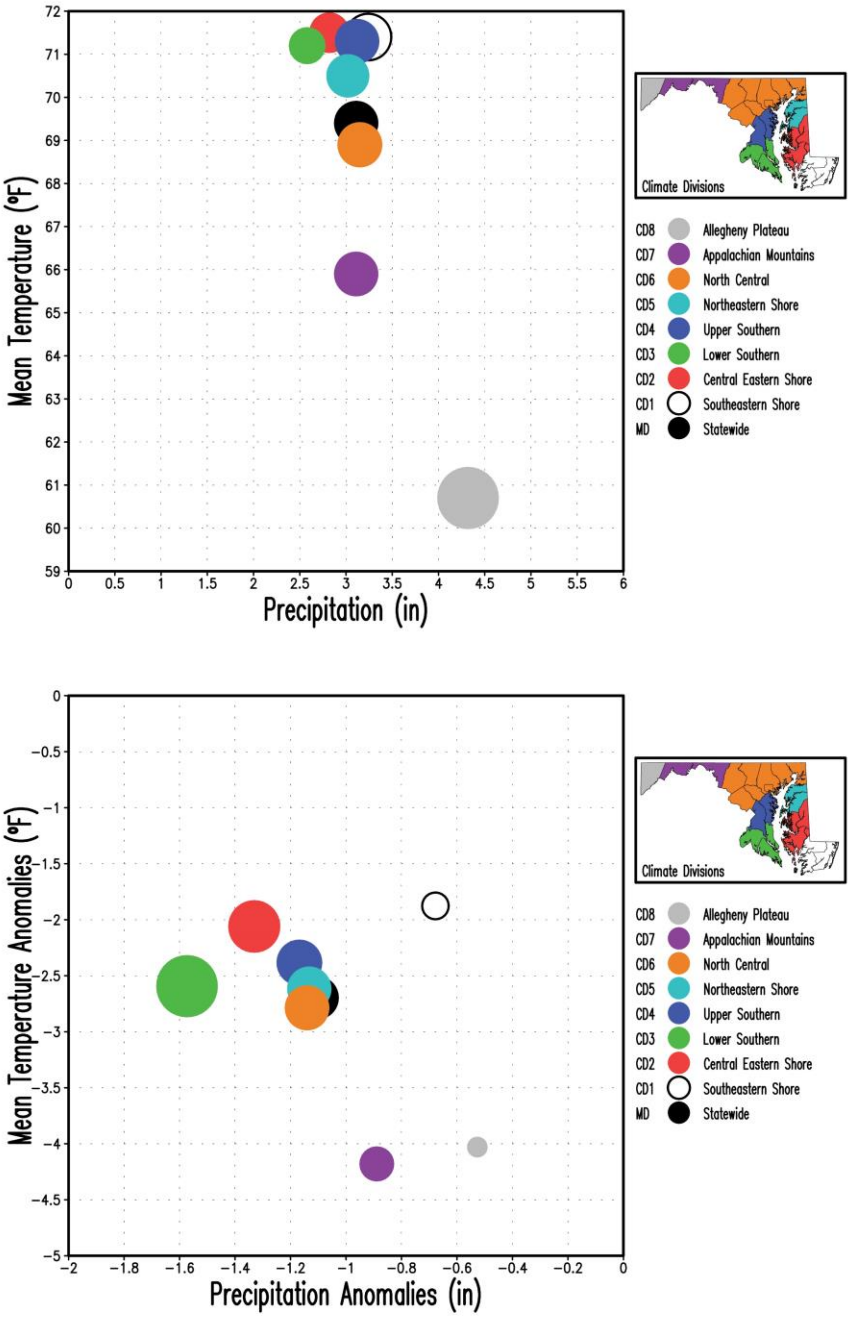

Figure 6. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for June 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 1991-2020 climatology. Temperatures are in °F and precipitation is in inches. The size of the circles is proportional to the total precipitation scaled down by the maximum precipitation (4.32 inches in CD8, top panel) and by the maximum precipitation anomaly (|-1.57| inches in CD3, bottom panel) among the nine regions. Note that the color of the filled circles corresponds to the color in the Climate Divisions according to the inset map.

B. April-June 2023 Scatter Plots

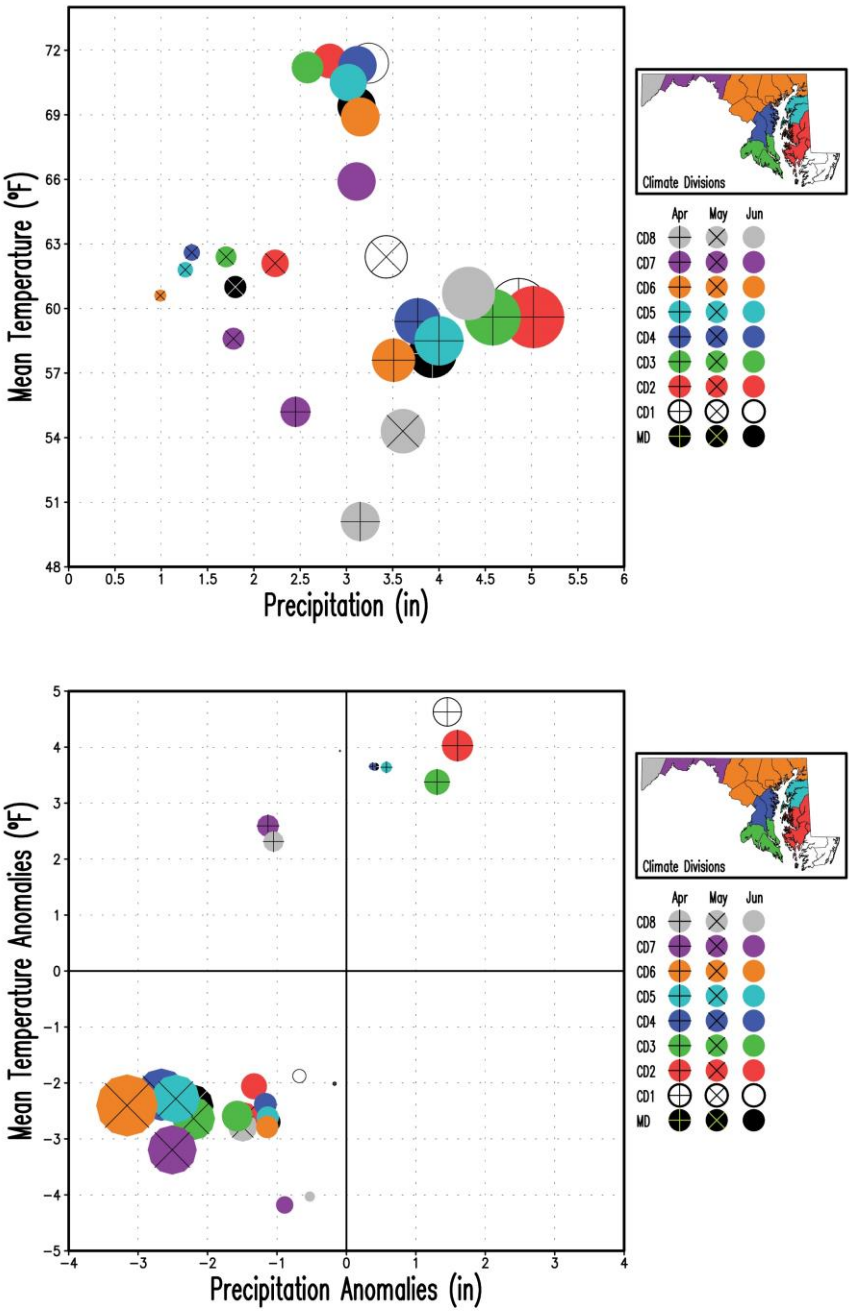

Figure 7. Scatter plots of Maryland (statewide) and Climate Divisions (CD#) monthly mean surface air temperature vs. total precipitation for April, May and June 2023. The upper panel shows the mean temperature and total precipitation, and the bottom panel displays their anomalies with respect to the 1991-2020 climatology. Temperatures are in °F, and precipitation is in inches. The size of the circles is proportional to the total precipitation scaled down by the maximum precipitation (5.02 inches in CD2 in April, top panel) and by the maximum precipitation anomaly (|-3.16| inches in CD6 in May, bottom panel) among the nine regions and three months. June is displayed with filled circles only, while May and April are displayed with superposed multiplication and addition signs, respectively.

5. June 2023 Statewide Averages in the Historical Record

A. Box and Whisker Plots

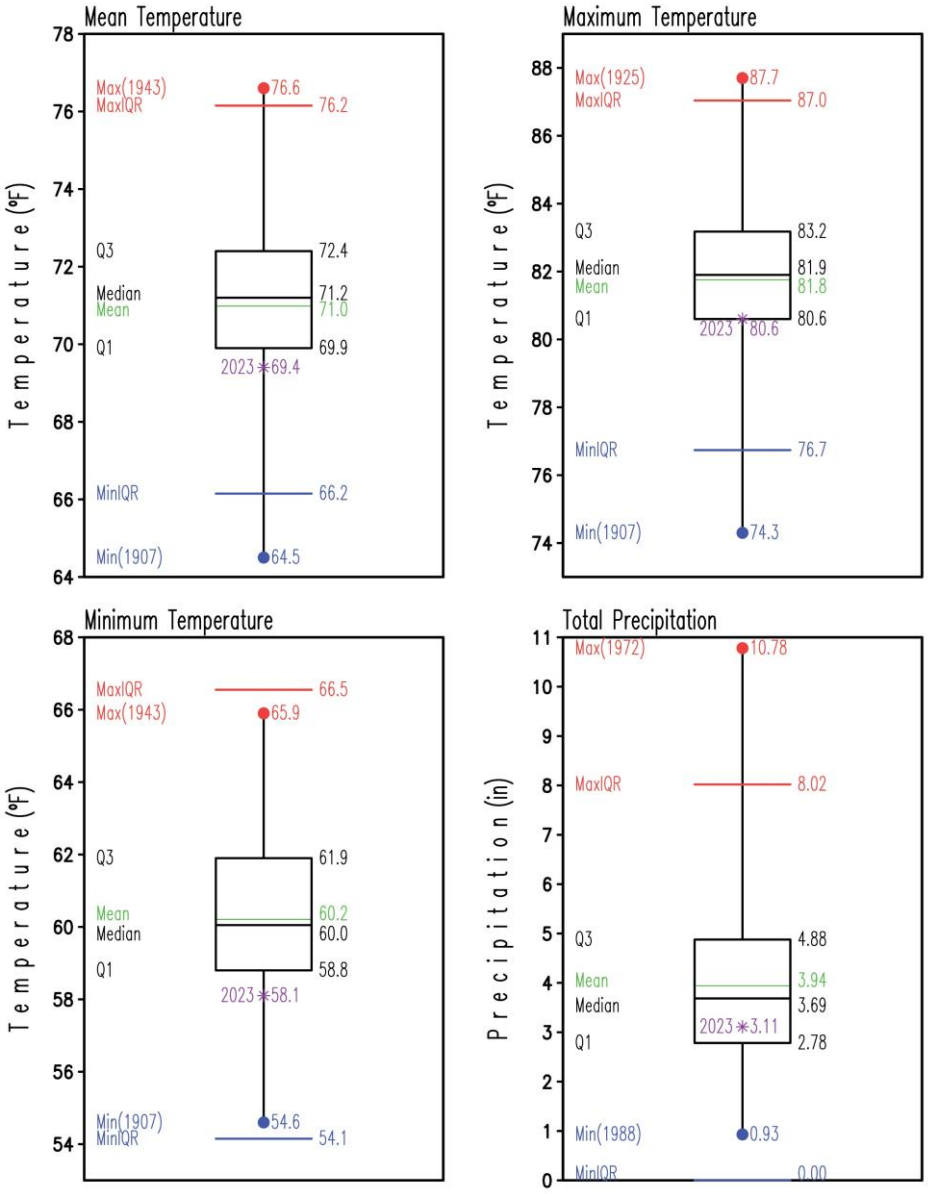

Figure 8. Box and Whisker plots of Maryland (statewide) monthly mean (upper left), maximum (upper right), minimum (lower left) surface air temperatures, and total precipitation (lower right) for June for the period 1895-2022. The label and asterisk in purple represent conditions for June 2023. Statistics for the period 1895-2022 are labeled at the left side of each box and whisker plot and their values at their right. Temperatures are in °F and precipitation is in inches. The mean is the green line within the box, while the median is the black line within the box. The lower (Q1) and upper (Q3) quartiles, indicating the values of the variable that separate 25% of the smallest and largest values are the lower and upper horizontal black lines of the box, respectively. The blue and red dots mark the minimum and maximum values in the period at the end of the whiskers; the year of occurrence is shown in parenthesis. The blue and red horizontal lines represent extreme values defined by Q1-1.5×(Q3-Q1) and Q3+1.5×(Q3-Q1), respectively.

6. 1895-2023 June Trends

A. Statewide Mean Temperature, Cooling Degree-Days, and Precipitation

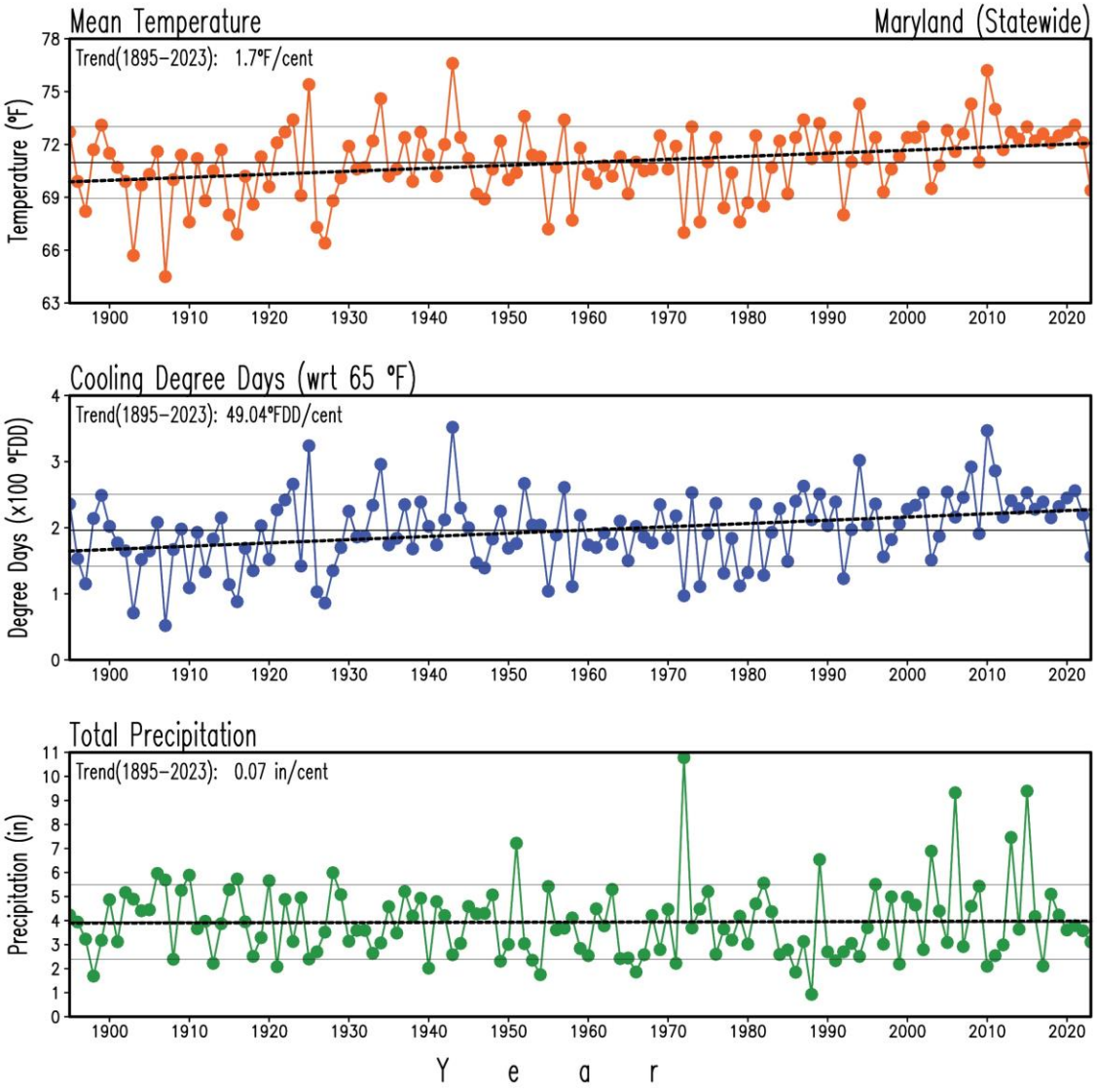

Figure 9. Maryland (statewide) mean surface air temperature, cooling degree-days, and precipitation in June for the period 1895-2023. Temperature is in °F, cooling degree-days is in °F degree-days (°FDD), and precipitation is in inches. The thin, continuous black lines in each panel display the long-term means (71.0°F, 196.08°FDD, and 3.94 in, 1895-2023), and the double thin, continuous gray lines indicate the standard deviation (2.0°F, 54.28°FDD, and 1.55 in) above/below the long-term mean. The thick dashed black lines show the long-term linear trend. Degree-days are the difference between the daily mean temperature (high temperature plus low temperature divided by two) and 65°F. It gives a general idea of how much energy is required to cool buildings; because energy demand is cumulative, degree-day totals for a month are the sum of each individual day's degree-day total (CPC, 2023). The warming temperature trend (1.7°F/century), and the increasing cooling degree-days trend (49.04°FDD/century) are statistically significant at the 95% level (*Student's t-test* –Santer et al. 2000) but not the small precipitation trend (0.07 in/century).

B. Temperature and Precipitation Maps

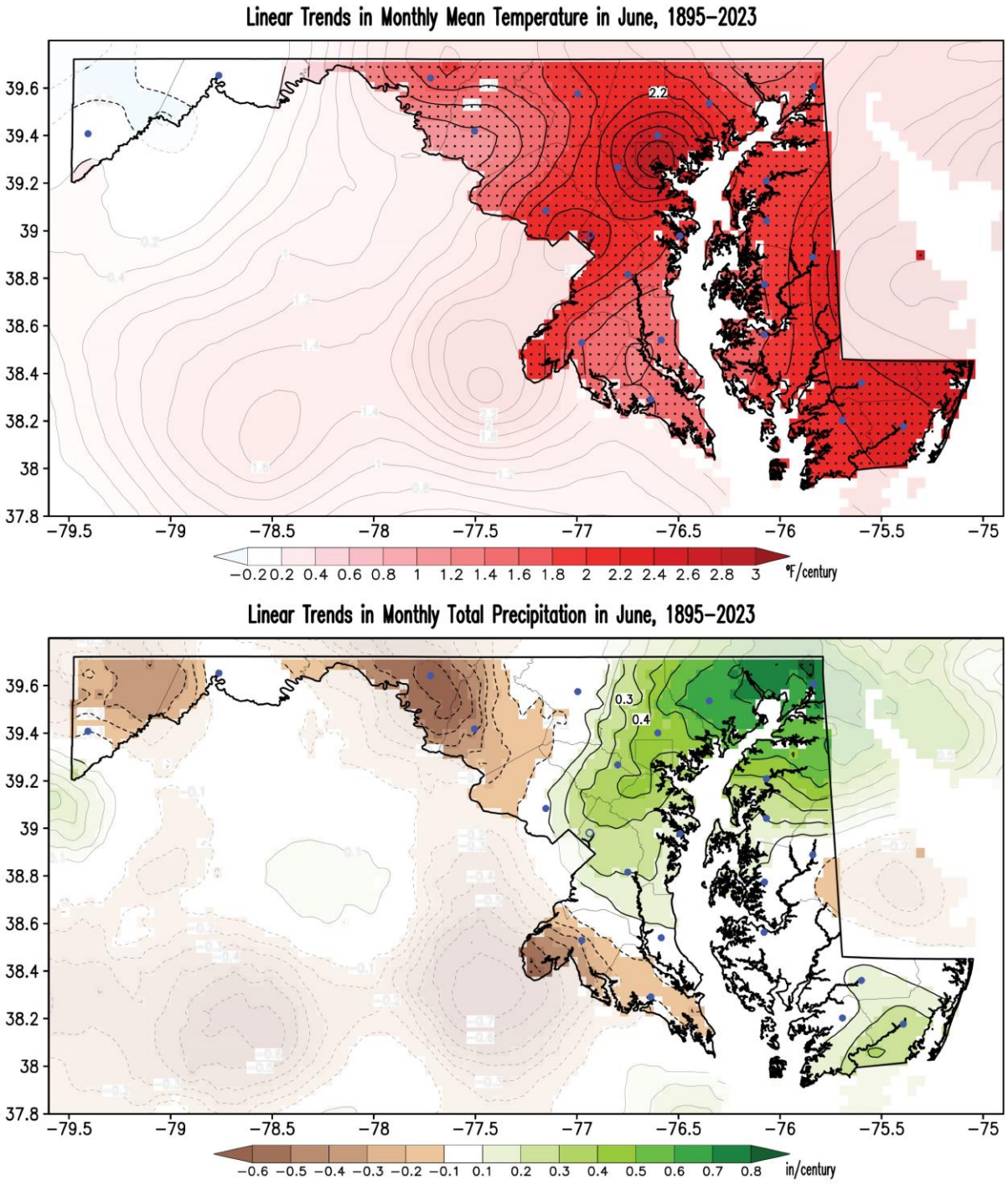

Figure 10. Linear trends in surface air mean temperature and precipitation in June for the period 1895-2023. Temperatures are in °F/century, and precipitation is in inches/century following the color bars. Blue/red shading in the temperature map marks cooling/warming trends. Brown/green shading in the precipitation map shows drying/wetting trends. Stippling in the maps shows regions where trends are statistically significant at the 95% level (*Student's t-test* −Santer et al. 2000). Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

Appendix A. June 2023 Tables: Statewide, Climate Divisions, and Counties

A. Mean Temperature and Precipitation

Region	Mean Air Temperature (°F)	Rank (#)
Statewide	69.4	27
Climate Division 1	71.4	49
Climate Division 2	71.5	41
Climate Division 3	71.2	25
Climate Division 4	71.3	33
Climate Division 5	70.5	29
Climate Division 6	68.9	27
Climate Division 7	65.9	9
Climate Division 8	60.7	10
Allegany	64.9	7
Anne Arundel	71.6	32
Baltimore	69.4	31
Baltimore City	71.7	45
Calvert	70.8	23
Caroline	71.1	46
Carroll	67.7	26
Cecil	69.6	31
Charles	71.3	27
Dorchester	71.7	39
Fredrick	67.8	19
Garrett	60.7	9
Harford	69.4	26
Howard	69.3	32
Kent	70.5	29
Montgomery	69.5	32
Prince George's	71.1	36
Queen Anne's	70.6	29
Saint Mary's	71.2	25
Somerset	71.8	43
Talbot	71.3	28
Washington	66.9	11
Wicomico	71.4	47
Worcester	71.0	51

Region	Total Precipitation (in)	Rank (#)
Statewide	3.11	46
Climate Division 1	3.24	60
Climate Division 2	2.82	43
Climate Division 3	2.58	29
Climate Division 4	3.12	48
Climate Division 5	3.02	51
Climate Division 6	3.15	43
Climate Division 7	3.11	43
Climate Division 8	4.32	60
Allegany	3.72	63
Anne Arundel	3.57	69
Baltimore	4.09	75
Baltimore City	4.63	93
Calvert	2.64	30
Caroline	2.81	40
Carroll	2.96	39
Cecil	4.12	78
Charles	2.64	32
Dorchester	2.84	38
Fredrick	2.21	19
Garrett	4.32	60
Harford	3.47	52
Howard	3.46	57
Kent	3.12	58
Montgomery	2.11	19
Prince George's	2.89	41
Queen Anne's	2.97	52
Saint Mary's	2.46	27
Somerset	3.54	67
Talbot	2.85	46
Washington	2.54	30
Wicomico	3.15	57
Worcester	3.10	57

Table A1. Monthly mean surface air temperature (left) and total precipitation (right) at Maryland (statewide), climate division, and county levels for June 2023. Temperatures are in °F, and precipitation is in inches. The rank is the order that the variable for June 2023 occupies among the 129 Junes after the 129 values have been arranged from the lowest to the highest in the *standard competition ranking method*. The closer to 129 the rank is, the larger (i.e., the warmer/wetter) the value of the surface variable is in the record; similarly, the closer to 1 the rank is, the smaller (i.e., the colder/drier) the value of the surface variable is in the record.

B. Maximum and Minimum Temperatures

Region	Maximum Air Temperature (°F)	Rank (#)
Statewide	80.6	32
Climate Division 1	81.9	65
Climate Division 2	82.4	50
Climate Division 3	81.5	27
Climate Division 4	82.1	37
Climate Division 5	81.2	28
Climate Division 6	80.7	38
Climate Division 7	78.8	15
Climate Division 8	72.6	17
Allegany	78.0	15
Anne Arundel	82.2	39
Baltimore	81.3	44
Baltimore City	83.0	61
Calvert	80.7	23
Caroline	82.7	53
Carroll	80.0	37
Cecil	80.8	38
Charles	81.9	31
Dorchester	82.6	55
Fredrick	79.8	32
Garrett	72.7	17
Harford	80.8	36
Howard	81.3	56
Kent	81.0	28
Montgomery	80.9	47
Prince George's	82.1	38
Queen Anne's	81.2	28
Saint Mary's	81.2	26
Somerset	81.8	58
Talbot	81.6	32
Washington	79.6	22
Wicomico	82.9	72
Worcester	81.2	65

Region	Minimum Air Temperature (°F)	Rank (#)
Statewide	58.1	21
Climate Division 1	60.8	34
Climate Division 2	60.4	31
Climate Division 3	60.9	30
Climate Division 4	60.6	30
Climate Division 5	59.8	31
Climate Division 6	57.1	14
Climate Division 7	53.0	1
Climate Division 8	48.6	3
Allegany	51.8	1
Anne Arundel	61.0	28
Baltimore	57.5	23
Baltimore City	60.4	28
Calvert	60.9	28
Caroline	59.4	39
Carroll	55.4	12
Cecil	58.4	20
Charles	60.7	34
Dorchester	60.8	31
Fredrick	55.6	7
Garrett	48.7	3
Harford	57.8	18
Howard	57.3	24
Kent	60.0	30
Montgomery	58.1	21
Prince George's	60.1	34
Queen Anne's	60.0	32
Saint Mary's	61.2	28
Somerset	61.8	39
Talbot	61.0	28
Washington	54.2	3
Wicomico	59.9	34
Worcester	60.7	38

Table A2. Monthly maximum (left) and minimum (right) surface air temperatures at Maryland (statewide), climate division, and county levels for June 2023. Temperatures are in °F. The rank is the order that the variable for June 2023 occupies among the 129 Junes after the 129 values have been arranged from the lowest to the highest using the *standard competition ranking method*. The closer to 129 the rank is, the larger (i.e., the warmer) the value of the surface variable is in the record; similarly, the closer to 1 the rank is, the smaller (i.e., the colder) the value of the surface variable is in the record.

Appendix B. June 2023 Bar Graphs: Statewide, Climate Divisions, and Counties

A. Temperatures and Precipitation

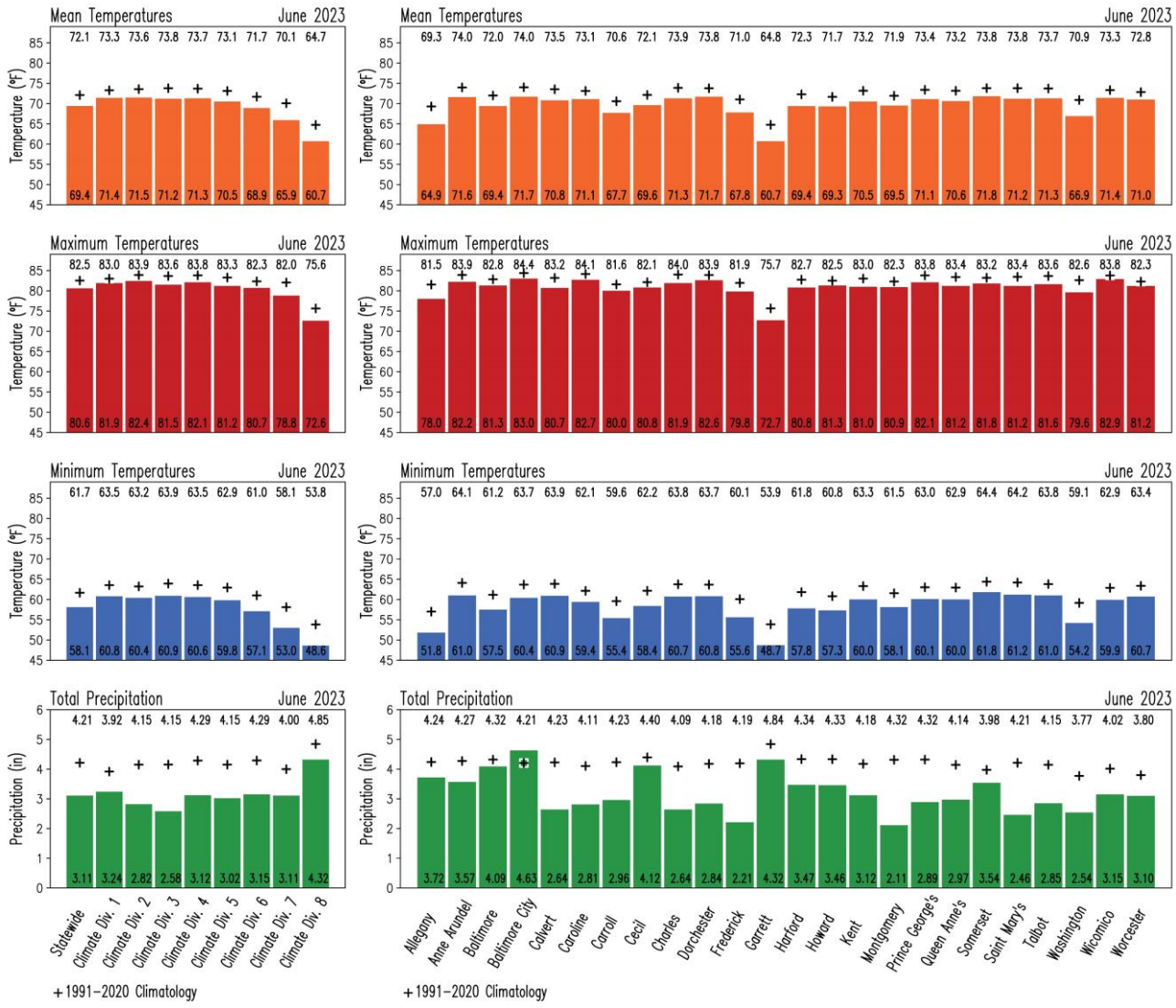

Figure B1. Monthly surface variables in Maryland for June 2023. Color bars represent the variables as follows: mean surface air temperature (orange), maximum surface air temperature (red), minimum surface air temperature (blue) and total precipitation (green) at statewide and climate division (left column), and at county (right column) levels. Temperatures are in °F and precipitation is in inches. The numbers at the base of the bars indicate the magnitude of the variable for June 2023. For comparison, the corresponding 1991-2020 climatological values for June are displayed as black addition signs, and their magnitude are shown at the top of the panels.

B. Temperature and Precipitation Anomalies

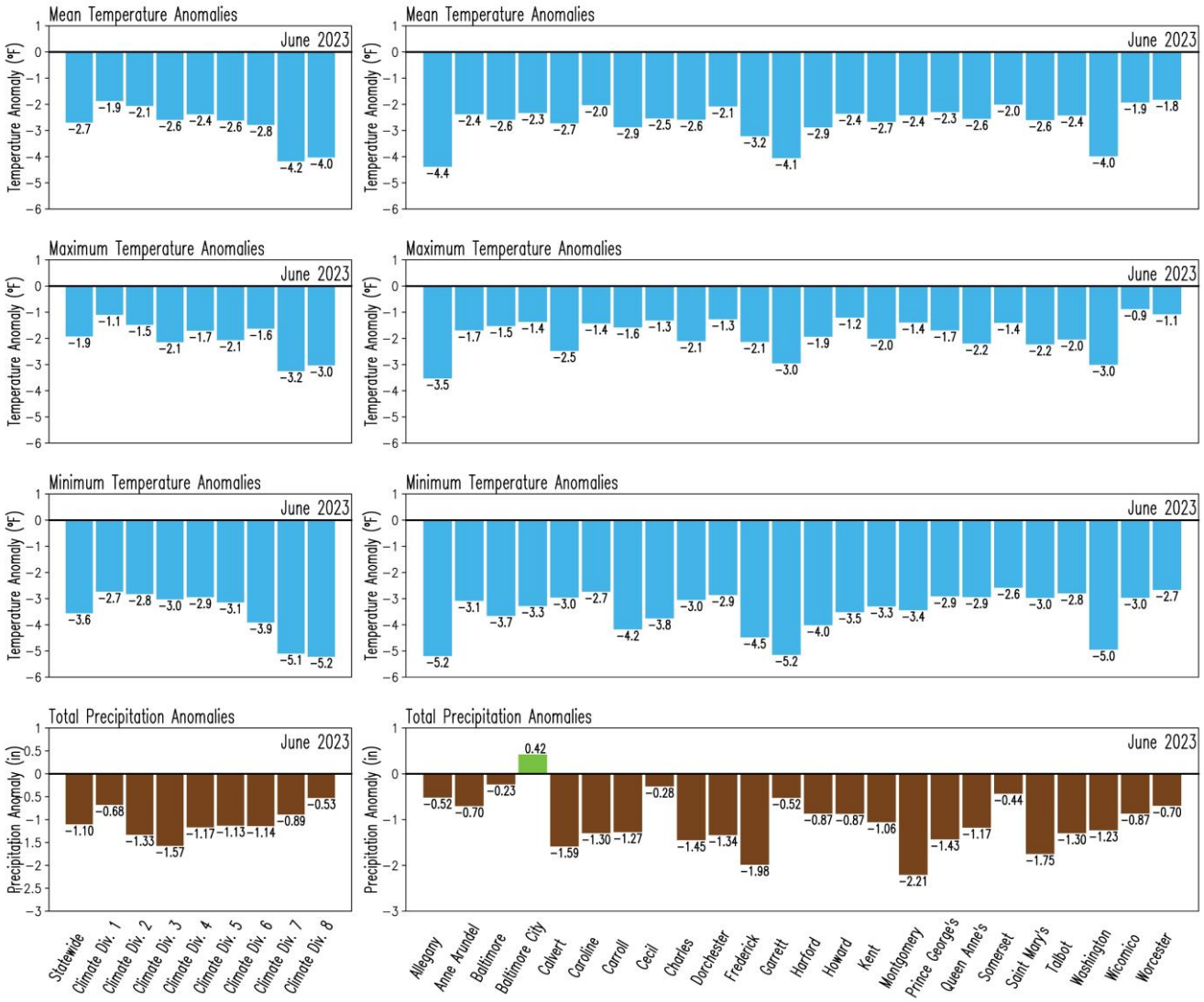

Figure B2. Anomalies of the monthly surface variables in Maryland for June 2023. Anomalies are with respect to the 1991-2020 climatology. Light blue color represents positive anomalies for mean surface air temperature (upper row), maximum surface air temperature (second row from top), and minimum surface air temperature (third row from top) while brown/green color indicates negative/positive anomalies in total precipitation (bottom row) at statewide and climate division (left column), and at county (right column) levels. Temperatures are in °F and precipitation is in inches. The numbers outside of the bars indicate the magnitude of the anomaly for June 2023.

Appendix C. June 1991-2020 Climatology Maps

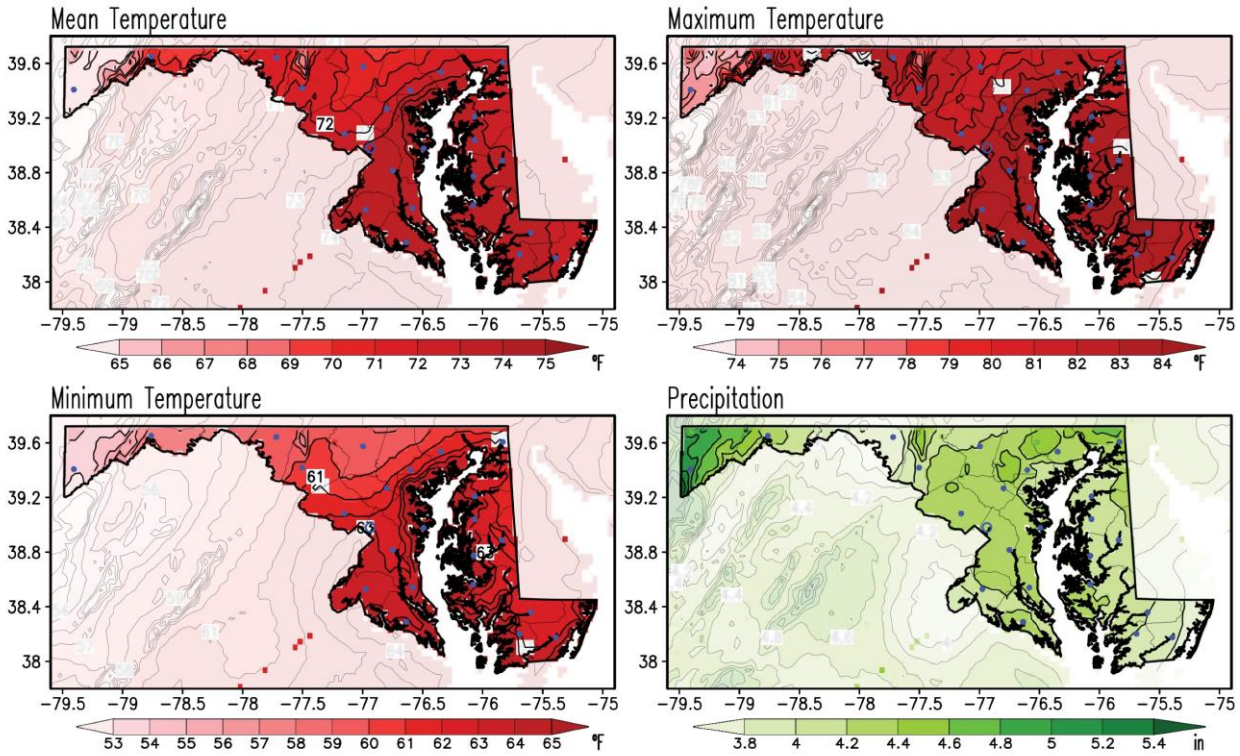

Figure C1. June climatology of the monthly mean, maximum and minimum surface air temperatures, and total precipitation for the period 1991-2020. Temperatures are in °F, and precipitation is in inches according to the color bars. This is the current climate normal against which the June 2023 conditions are compared to obtain the June 2023 anomalies. Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

Weather and climate are closely related, but they are not the same. Weather represents the state of the atmosphere (temperature, precipitation, humidity, wind, sunshine, cloudiness, etc.) at any given time. On the other hand, climate refers to the time average of the weather elements when the average is over long periods. If the average period is long enough, we can start to characterize the climate of a particular region.

It is customary to follow the World Meteorological Organization (WMO) recommendation and use 30 years for the average. The 30-year averaged weather data is traditionally known as Climate Normal (Kunkel and Court 1990), which is updated every ten years (WMO 2017). Establishing a climate normal or climatology is important as it allows one to compare a specific day, month, season, or even another normal period with the current normal. Such comparisons characterize anomalous weather and climate conditions, climate variability and change, and help define extreme weather and climate events (Arguez et al. 2012).

Appendix D. June Standard Deviation and June 2023 Standardized Anomalies Maps

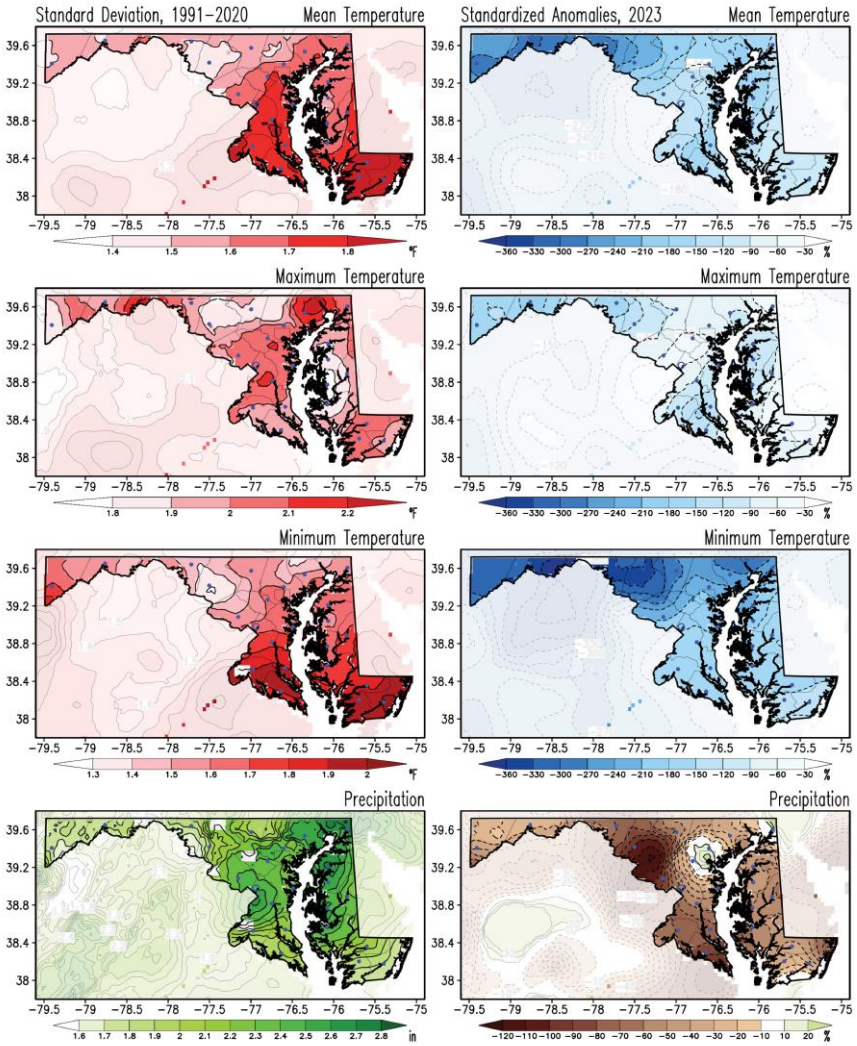

Figure D1. Standard deviation for June and standardized anomalies of temperatures and precipitation for June 2023. Standard deviations for monthly mean, maximum, and minimum surface air temperatures and total precipitation were obtained for the 1991-2020 period (left column). Anomalies for June 2023 (right column) are obtained as a percentage of the standard deviations. The standard deviations in temperatures are in °F, and those in precipitation are in inches according to the color bars. Blue shading in the anomaly temperature maps marks colder than normal conditions; brown/green shading in the anomaly precipitation map marks drier/wetter than normal conditions. The standardized anomalies are obtained by dividing the raw anomalies (from Figures 1 to 4) by the standard deviation (from left column panels) and multiplying that ratio by 100; hence units are in percent (%). Note that shading outside the state has been washed out to facilitate focusing on Maryland. Filled blue circles mark the county seats.

The monthly standard deviation measures a climate variable's year-to-year, or interannual, variability. Anomalies are sometimes compared against that variability to identify extremes in the climate record. When the anomalies are divided by the standard deviation, they are named *standardized anomalies*.

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